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Finer Points

SUPERABRASIVE INDUSTRY REVIEW

INTERTECH 2013 Review

THIS ISSUE

A Finer Point of View

INTERTECH 2013 Review

News & Notes

Paper Excerpts from INTERTECH 2013

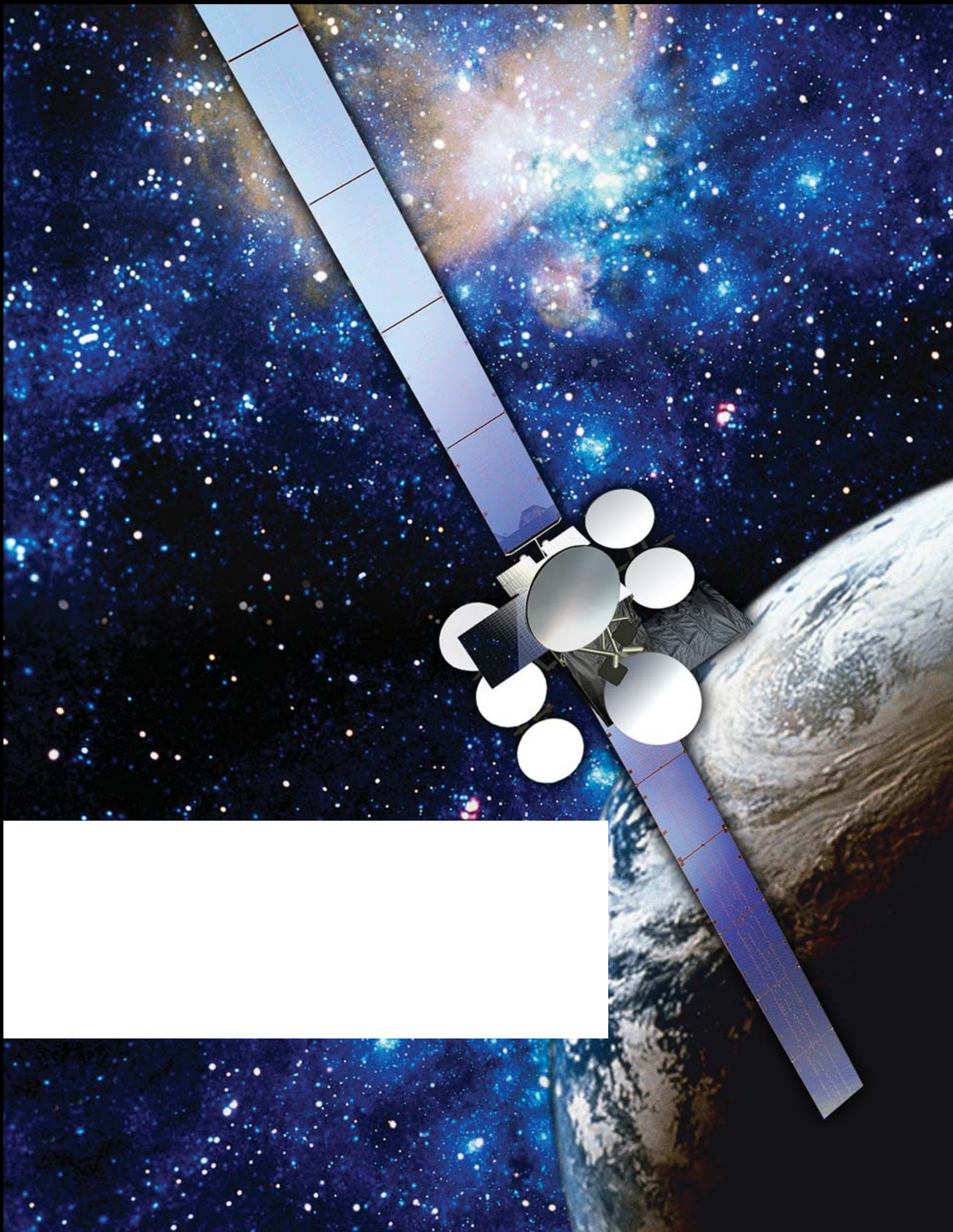
Engis Celebrates 75th Anniversary

IDA Member Companies

Calendar of Events

News Products

Membership Application



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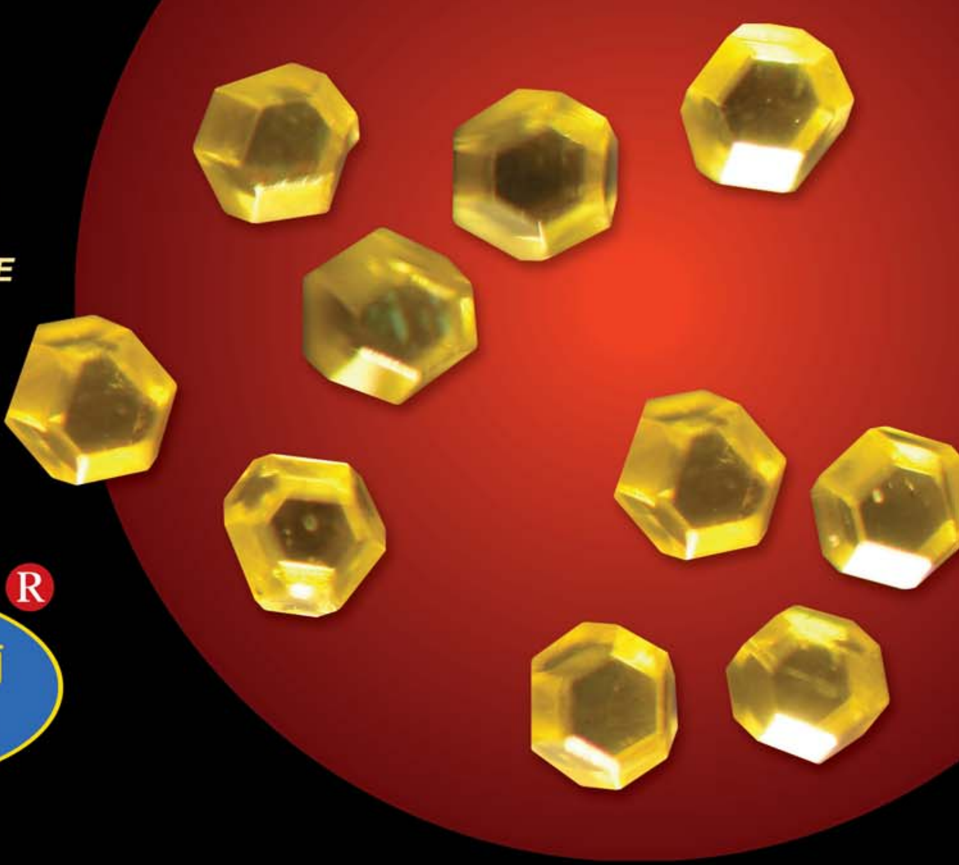

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Finer Points

departments

4 A Finer Point of View
6 Editorial
12 News & Notes
23 New Products
24 Ad Insertion
29 Membership Application

COVER PHOTO

Photo Courtesy of Boeing showing broadcasting satellite DIRECTV 12. DIRECTV significantly expands DIRECTV's HDTV broadcasting to consumers throughout the continental United States, Alaska and Hawaii. DIRECTV 12 features two Ka-band payloads for national and spot beam coverage, which will enable DIRECTV to deliver 200 national HD channels and 1,500 local HD channels to millions of U.S. households." Aerospace was featured at INTERTECH 2013 and Boeing was a major participant at INTERTECH.

feature articles

8 INTERTECH 2013 Review
10 Paper Excerpts from INTERTECH 2013
15 Engis Celebrates 75th Anniversary
16 IDA Member Companies
18 Paper Excerpts from INTERTECH 2013
21 Calendar of Events

FINER POINTS is the longest running publication devoted exclusively to the understanding, selection and application of diamond, cubic boron nitride and related materials. It is edited for recipients who are involved in some way with these "superabrasives", either as providers of the materials, producers of products containing the materials or users of these products (e.g., grinding wheels, dressing tools, drill bits, saw blades, sawing wires, cutting tools, polishing compounds, CVD film products, etc.).

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ABC Warren Superabrasives Saint-Gobain Surface Conditioning Group	13
Apogee Precision Parts	9
Bogimac NV-SA	6
DCM-TECH, Inc.	28
Element Six	OBC
Engis Corporation	IBC
ILJIN USA, Inc.	17
Lieber & Solow, Co.	5
Ulbrich Stainless Steels and Special Metals, Inc.	23
Worldwide Superabrasives, LLC	7
Zhongnan Diamond Co., Ltd.	IFC

A Finer Point of View…

We just completed another very successful INTERTECH and since the turn of the century INTERTECH has been THE conference for developments and application for diamond and cubic boron nitride. I would be remiss if I did not specifically thank our hard working Planning Committee of David Spelbrink, Scott Ries, Steve Griffin, Joe Connolly and Keith Reckling. Of course our Technical Advisory Committee headed up by Ion Benea did another outstanding job of reviewing and selecting papers for this event, their work helped make this such a great technical experience. Our Executive Director, Terry Kane has served as the INTERTECH Chairman for over 13 years and his work and the work of Kathy Kane our Meeting Planner continues to be invaluable.

In 2013 our Planning Committee introduced a new look to INTERTECH, featuring one of the major industries we serve. In 2013 that happened to be aerospace and the papers reflected the new and exciting applications for superabrasives in this industry. Of course other topics and papers were also well represented from the automotive industry to scientific research and everything in between. As always INTERTECH represented the best of our industry both from a technology standpoint and the networking of attendees from all around the world. The term "melting pot" may sometimes be over used but those who experienced INTERTECH saw it as melting pot cultures, disciplines, businesses and ideas. INTERTECH was the brainchild of a forward thinking Board of Directors in the late 90's and I am happy to report we have continued to build and grow. Never once have we settled for the success of one conference, instead we have always looked to the future and every Board over the past 14 years placed an indelible stamp of its own upon each INTERTECH. That is why we now focus on 2015 with an even greater expectation for what may be and what the future has in store at INTERTECH 2015. Our Board has not rested and is already into the planning stages for INTERTECH 2015. The location will be Indianapolis, Indiana and INTERTECH will be a precursor to the most famous racing event in the world, The Indianapolis 500, after all, it is "The Greatest Spectacle in Racing"! What a great time and place to be! Needless to say the Board has already been toying with ideas and possibilities of tie-ins, speakers and topics given this momentous occasion. If the automotive world will be showing all the technology and muscle it has to offer, should we not match that intensity?

PRESIDENT
Mike Mustin

As we move forward I would like to remind all IDA Members that we welcome participation and suggestions, the Board may lead your Association, but you make up the heart and soul of what we are!

Every INTERTECH we get at least one new member that sees the IDA in action first-hand and realizes the value in that Association to its members. Hopefully we will see a couple more who have also expressed interest ... If you are not currently an IDA Member why not? Where else can you get someone to work for your best interests 24/7 365 days a year! You can call any of our Board, our Executive Director or me. Any of us will be happy to discuss the benefits of being an IDA Member. It is a positive move worth making.

Sincerely,

Mike Mustin
Industrial Diamond Association of America

Industrial Diamond Association of America, Inc.

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A Lack of Kinder and Gentler

TERRY KANE, Editor

"Prosperity with a purpose means taking your idealism and making it concrete by certain acts of goodness. It means helping a child from an unhappy home learn how to read - It means teaching troubled children through your presence that there's such a thing as reliable love. Some would say it's soft and insufficiently tough to care about these things. But where is it written that we must act as if we do not care, as if we are not moved? Well I am moved. I want a kinder, gentler nation."

George H. W. Bush, 41st President of the United States

Kinder and gentler would make for a much better workplace and world! Wouldn't it be great if there was a renewed trust like the way we did business in the past, where a handshake or a verbal agreement was binding because of mutual trust? Wouldn't it be great if after you spent months and months of working with a customer to establish a workable operation that they did not take the first opportunity to change suppliers for a "lowball" offer. Yes, commitment and trust was a good thing!

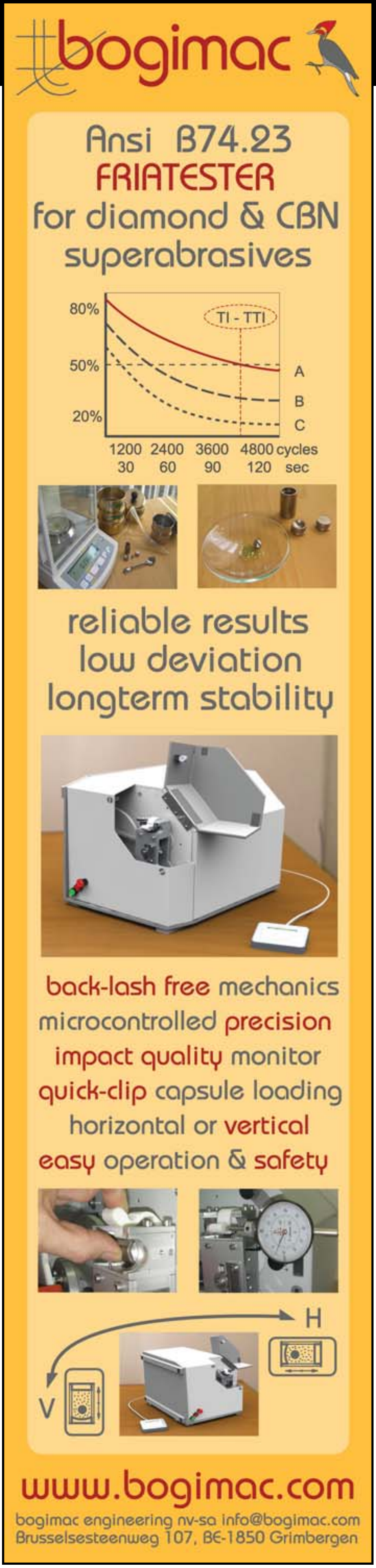
We have reached a very unsettling time in our history. Trust and security have passed us by. The time of unlocked doors, caring for each other and the common good have given way to mistrust, deadbolts and high-tech security systems. In the 1970's we had an honor system coffee room and the coffee, candy and chips were all there for everyone to take and pay in a small jar. This honor system stood for over two decades without a single loss. It finally had to be eliminated because people started helping themselves without paying and even emptying the money jar ... Such a shame!

Kinder and gentler have been left by the wayside. Violence has found its way into our schools, workplaces and at sporting events where we go to relax and enjoy ourselves.

I read in horror about the little league baseball coach that led his team in an assault upon the umpire severely injuring him with bats and punches rained by the team of 12 year olds. Last basketball season criminal charges were brought against another youth coach who led his team in an all-out assault against two basketball officials. Then recently the headlines of the sports pages were awash with the report of a soccer official that was punched in the face by a teenager and subsequently died after the violent attack. These cases are just the tip of a horrific iceberg of incidents indicating an ongoing trend.

I won't even get into the catastrophes at our schools, movie theaters, malls and even the Boston Marathon ... Those go to a different level of insanity!

The workplace has become another cause for concern. We have heard incidents of workplace attacks and shootings to where everyone understands "going postal" means another crazy at the workplace! Is there an answer? Maybe not. As one psychologist recently pointed out it comes down to the fact that many youths and adults have never had to interact with any real authority figures. These are the first people to tell a kid "no" so kids and some adults instantly dislike authority and are more prone to lash out at them. Many parents do not have the strong authority approach or command the respect we saw years ago and they are raising a generation that cannot deal with life and the day to day structure required in the workplace and life itself. Kinder and gentler have become a lost ideal ... It now boils down to "watch your back" ...



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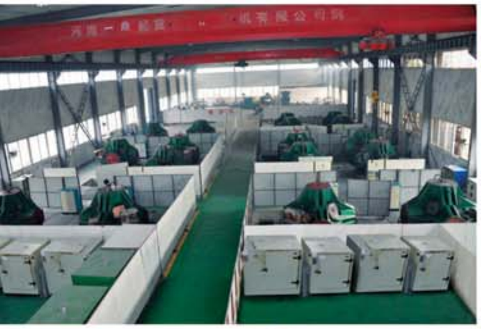
THE FUTURE OF SUPERABRASIVES

- WWSA (Worldwide Superabrasives, LLC) and our joint venture partner, BESCO Superabrasives, proudly announce the expansion of our manufacturing facility in Kaifeng, China.
- WWSA/BESCO, which was founded in 2008, has made a significant investment to increase our plant capacity by over 80% to 60,000 square feet to meet customer demand.
- Included in our expansion is our new superabrasive raw material catalyst production facility—continuing our goal of controlling every part of the superabrasive manufacturing process.
- WWSA/BESCO will produce over 140,000,000 carats of the highest quality resin bond industrial diamond and Cubic Boron Nitride (CBN) in 2012 at our Kaifeng factory.
- WWSA/BESCO will increase the expansion of our manufacturing capacity to no less than 180,000,000 carats by the end of 2013.
- Recent reports indicate that approximately 90% of superabrasive raw materials are manufactured in China—regardless of the name on the label.
- WWSA/BESCO is in a very powerful position for many years into the future as a manufacturer of the highest quality superabrasive raw materials and a provider of world-class technical support, product delivery and customer service.
- IN SUMMARY, WWSA/BESCO will play a significant role in the future of the supply of superabrasive raw materials.



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INTERTECH 2013

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www.intertechconference.com

Hyatt Regency Baltimore Harbor
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May 6, 7 & 8, 2013

INTERTECH 2013 FEATURED RESEARCH IN SUPERABRASIVES TECHNOLOGY AND MAJOR DEVELOPMENTS FOR INDUSTRIAL MANUFACTURING IN AEROSPACE APPLICATIONS

The Industrial Diamond Association of America (IDA) recently hosted another successful INTERTECH Conference. Those who were lucky enough to attend were treated to some outstanding Keynote addresses from leading aerospace and material manufacturers. The audience leaned much about the aerospace industry and its growth as well as very insightful presentations on titanium and composite manufacturing. We also had the opportunity to listen to one of the diamond industries leading researchers and historians. Keynotes were definitely well worth the price of admission. The technical sessions were both diverse and held the interest of all attendees as the outstanding presentations ranged from polycrystalline and crystal developments to CVD and cBN coatings for new applications. Over 190 attendee representing 90 companies from 20 different countries showed up to hear all about the latest superabrasive technology and new application developments.

The final day saw another well-structured education session and attendees took in all the history, market information and product application for grinding and machining products. Each day everyone had the opportunity to visit a range of tabletop exhibits and discuss product and services available to the industry. Of course one of the strengths of INTERTECH is the networking provided through dining and social events for attendees. Attendees were asked to complete a survey and INTERTECH received outstanding marks and exceptional praise for all aspects of the conference, including content, location and amenities.

Most attendees are looking forward to INTERTECH 2015 and they will not be disappointed. INTERTECH has spent the last 13 years building up its excellent base of presenters and attendees and the future looks bright for this mainstay in the superabrasives industry. Every INTERTECH has its own signature and draw and in May of 2015, we will continue this tradition as INTERTECH 2015 will be a precursor to The Greatest Spectacle in Racing, the INDIANAPOLIS 500. Planning is underway and you need to make your plans. See you at INTERTECH in May of 2015 Indianapolis, Indiana USA, you will not be disappointed!

Keynote Dr. Dianne Chong of Boeing gave an overview of aerospace manufacturing.

Sessions were full to hear technical developments.

Tabletop displays were of great interest.

Attendees enjoyed networking at conference events.

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Paper Excerpts of INTERTECH 2013 on the following pages.

Crystallographic Defects and Mechanical Strength of Micron Size Monocrystalline Diamond

Ion C. Benea, Ph.D. and Benjamin R. Rosczyk
Engis Corporation, Wheeling, IL 60090, USA

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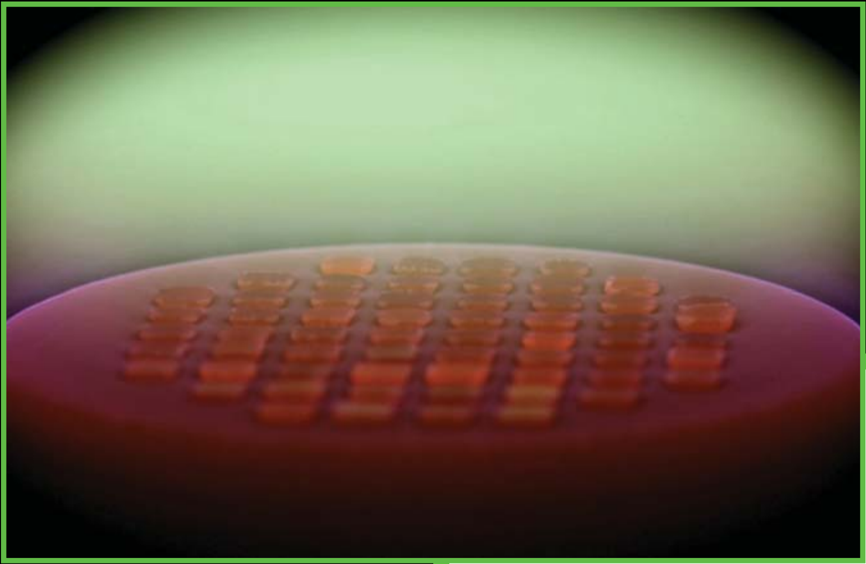
ABSTRACT

Mechanical strength of a diamond particle characterizes its ability to resist fracture under static or dynamic (impact) loading. Mechanical strength of monocrystalline diamond is dependent upon particle size, particle shape and crystallographic defects. For a given size and shape, the mechanical strength of diamond particle is directly related to the concentration of crystallographic defects.

This work established that the FTIR baseline transmittance, defined as transmission at 2670 cm-1, represents a good measure of the concentration of crystallographic defects, which is directly related to the mechanical strength of micron size monocrystalline diamond powders.

INTRODUCTION

Crystallographic defects in the crystal lattice of diamond are common. Crystallographic defects or crystal growth defects of diamond are the result of the nucleation and crystal growth processes that govern the catalytic high pressure-high temperature (HPHT) graphite to diamond transformation (so called diamond synthesis process). The intrinsic properties of diamond crystals are determined by the particularities of the catalytic HP-HT synthesis process; mainly the nucleation and growth rates. For a given graphite-metal catalyst system the kinetics of the diamond synthesis process (nucleation and growth rates) is controlled via thermodynamic parameters pressure and temperature. Diamond crystals with low concentration of crystal growth defects and high mechanical strength are synthesized under pressure-temperature conditions that generate low nucleation and growth rates. By contrast, diamond crystals with high concentration of crystal growth defects and low mechanical strength are synthesized under pressuretemperature conditions that generate high nucleation and growth rates. Crystallographic defects (substitutional or interstitial impurities, vacancies, dislocations, etc.), are sources of mechanical stresses, thus contributing to the mechanical strength and fracture characteristics of monocrystalline diamond particles. Most micron size monocrystalline diamond powders are produced by size reduction (milling) of the mesh size diamond powders (so-called diamond feeds). During micronizing process which consists of mechanical, chemical and thermal process steps, a large number of the initial crystal growth (CG) defects of the starting mesh diamond powder feed, are released. Nevertheless, some of the crystal growth (CG) defects of the starting mesh diamond powder are transmitted to the resultant micron diamond powder, as residual crystal growth (RCG) defects. The mechanical strength of the micron diamond powders can be controlled by controlling the nature and concentration of the crystal growth defects of the starting mesh diamond feed, by way of feed quality. For a given size and



High Volume Single-Crystal Diamond for Industrial Applications

AL GENIS, VP/Director of Technology
Scio Diamond Technology Corporation

The demand for robust and precise parts of hard to machine alloys is steadily growing. The ability of mature fabrication industries to economically produce these parts requires access to unique and scarce super hard materials. These materials must be able to stand up to these new metals and alloys, be capable of maintaining high accuracy, and be cost effective. The availability of mass-produced Chemical Vapor Disposition (CVD) diamond can lead the path forward to address these issues for the development and fabrication of new products. Recently, a major supplier has been able to reduce a three-step process to a single step by taking advantage of the superior performance of diamond cutter blades. This achievement facilitated a multi-million dollar sales agreement with an international supplier of precision diamond tool products.

Beyond its application in fabrication and product manufacturing, single-crystal CVD diamond also has a long and rapidly growing list of industrial and technological applications where the diamond itself is the product. These include high-power high-frequency electronics, prisms for high-index waveguides, Quantum Electrodynamics, Raman spectroscopy, P/N junctions, electronics, radiation detectors for X-Rays, and femtosecond laser experiments. In addition, optical grade windows and prisms, high thermal conductivity heat sinks, diamond sheets for X-Ray windows and CVD diamond as a basis for electronics Biosensors. Working with partners in the medical device field has shown the Ophthalmology and Plastic Surgery communities worldwide that the precision and durability available in CVD diamond scapels exceeds anything available with current technology.

Single-Crystal Diamond

To meet this diverse and increasing demand, CVD single-crystal diamond growth technology is rapidly expanding. The intrinsic advantage of CVD diamond is the ability to provide customizable enhancements. Growth recipes can be designed to control the amount of stress, hardness and color or transparency required for each application. This is not available with natural diamond and rarely available with HPHT material. The capability to provide stronger diamond materials, in mass-fabricated quantities with a consistency not achievable using natural or HPHT diamond opens up almost endless new possibilities for industrial applications.

There are several types of CVD reactors, but those that can customize their reactors to grow on a wide variety of substrate crystal sizes have unparalleled growth potential. The proprietary CVD reactor design developed by Scio Diamond has seen unprecedented expansion in its growth capability; scaling up from 16 crystals to 60 crystals per run as seen in figure 1 below. Utilizing larger seeds, from 4.5mm to 10mm, more than doubles the current product manufacturing. Additional scaling is planned using mosaic technology where two or more diamond seeds are joined together seamlessly. The ability to form very large seed crystals allows the current platform to produce significantly more product and become more and more cost effective.

The combination of increased seed size and the ability to grow continuously for hundreds of hours provides sufficient thickness, enabling multiple product pieces to be extracted from a single crystal. For example, going from 4mm x 4mm seeds to 7mm x 7mm seeds increases the output of industrial cutter blades by 60%. When you increase to roughly 10mm x 10mm seeds, production increases another 31%. All in all, a 110% increase using the same equipment and growth cycle. In addition to scaling seed crystals, high production can be attained by utilizing larger CVD reactors. Going from a 3-inch platform to a 4-inch platform potentially increases yield by yet another 50%.

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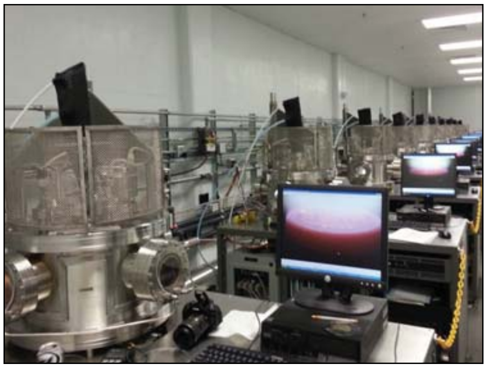

NEWS and notes

DETROIT GOES BANKRUPT, LARGEST MUNICIPAL FILING IN U.S. HISTORY

Once known as the “Paris of the West” and home to America’s bustling auto industry, Detroit filed for bankruptcy after fighting steady decline for half a century.

Detroit filed the largest municipal bankruptcy in the nation’s history, marking a new low in a long decline that has left the U.S. automaking capital bleeding residents and revenue while rendering city services a mess. The city, which was the nation’s fourth-largest in the 1950s, with nearly 2 million inhabitants, has seen its population plummet to 700,000 as residents fled rising crime and deteriorating basic services. It is possible to emerge successfully from bankruptcy. A conscious, deliberate reconstruction plan can put a municipality on firmer footing. Orange County, for example, emerged from its 1994 bankruptcy within a year, and nine years later had a triple-A bond rating.

LACH DIAMOND AT THE EMO 2013 IN HANNOVER

In 2012 Lach celebrated the company‘s 90th anniversary, another anniversary takes place this year: 40 Years of pioneering achievement worldwide in the development of polycrystalline diamond tools. At the Hannover Spring Fair in 1973 LACH DIAMANT for the first time introduced a PCD tool for the turning of aluminum parts with interrupted cut. This was accomplished in a dry cut mode with an infeed of max. 3.4 mm. This demonstration was a sensation for the trade show visitors at that time. The triumphant success of polycrystalline diamond tools, accompanied by the tireless pioneering work of LACH DIAMANT, took its course and continues today. In 1973 the manufacturers of copper commutators for the electric motors industry quickly recognized the economic and quality improving properties of PCD tools and the automobile, plastic, wood and fiber composites, aircraft and wind turbine industries also applied these PCD tools. At the LACH DIAMOND booth at the EMO from September 16 to 21, 2013, the visitor, will be able to see the traditional PCD cutting tools for turning, drilling, milling, but also will be introduced to new developments under the slogan “Future for Today”.

LACH DIAMOND

20TH ANNIVERSARY OF ROLLOMATIC INC. IN THE USA BY FOCUSING ON THE FUTURE

ROLLOMATIC®
Precision CNC Tool Grinding Machines

Mundelein, IL, June 2013. Rollomatic, a leading CNC machine tool manufacturer based in Switzerland, is announcing its 20th anniversary of the date of incorporation in the state of Illinois, USA on June 8th, 1993. In celebration of this milestone, Rollomatic will hold an Open House event from November 5th to 7th, 2013. On Wednesday night, Nov. 6th, Rollomatic will host a festive celebration in form of a gala where all attendees of the Open House will be invited. Rollomatic specializes in building CNC tool and cylindrical grinding machines for the grinding and manufacturing of precision rotary and indexable cutting tools. The company’s grinding centers, ranging from 3-axis to 13-axis models, can provide customized solutions to particular requirements in the industrial, medical and dental fields. User-friendly software developed in-house is available for small- and large-batch tool grinding. www.rollomaticusa.com

VOLLMER INTRODUCES NEW EROSION TECHNOLOGY FOR DIAMOND TOOLS

VOLLMER

Vollmer is proud to introduce the Vpulse generator on the newly designed QXD250 rotary erosion machine. This generator processes diamond tipped tools 30% faster than previous machines. Finer surface finishes down to 0.1µRa are also possible with this new technology. The QXD platform continues to be the benchmark for complete diamond tool production, offering six CNC controlled axes which operate simultaneously to produce optimum results on tools in a single set up. PCD drills, endmills, reamers and milling cutters with diameters up to 320mm and lengths up to 250mm can be measured, ground, eroded and polished with no operator interaction. The modular automation allows the machine to be operated with a combination of six electrodes and/or grinding wheels. The computer stores these dimensions which reduces operator requirements and allows multiple geometries to be machined. The modular pallet system for tool delivery can hold up to 28 individual tools and utilizes RFID technology to match the tool carrier with the desired machining program. This machine will make its North American debut at the AWFS show in Las Vegas July 24th – July 27th. Individual demonstrations can also be arranged at the Vollmer of America facility in Carnegie, Pennsylvania beginning in August. www.vollmer-us.com

Development of CBN Tool for Machining Heat Resistant Alloy

TSUTOMU HIRANO, KATSUMI OKAMURA, TOMOHIRO FUKAYA,
Sumitomo Electric Hardmetal Corp. Itami, Hyogo, Japan

RICH MATON - Engineering Manager,
Sumitomo Electric Carbide Inc. USADAVID SLUTZ – Morgan Technic

SUMITOMO
CARBIDE - CBN - DIAMOND

Abstract

The demand for high efficiency machining of heat resistant alloy is increasing in aerospace industry. In the machining of heat resistant alloys, notch damage at the side cutting edge often causes shortening of tool life. To solve this issue, a new CBN tool has been developed. This CBN tool shows good flank wear resistance and notch wear resistance for machining heat resistant alloy such as Inconel718. As a result, this CBN tool achieved two times longer tool life than that of conventional CBN tool.

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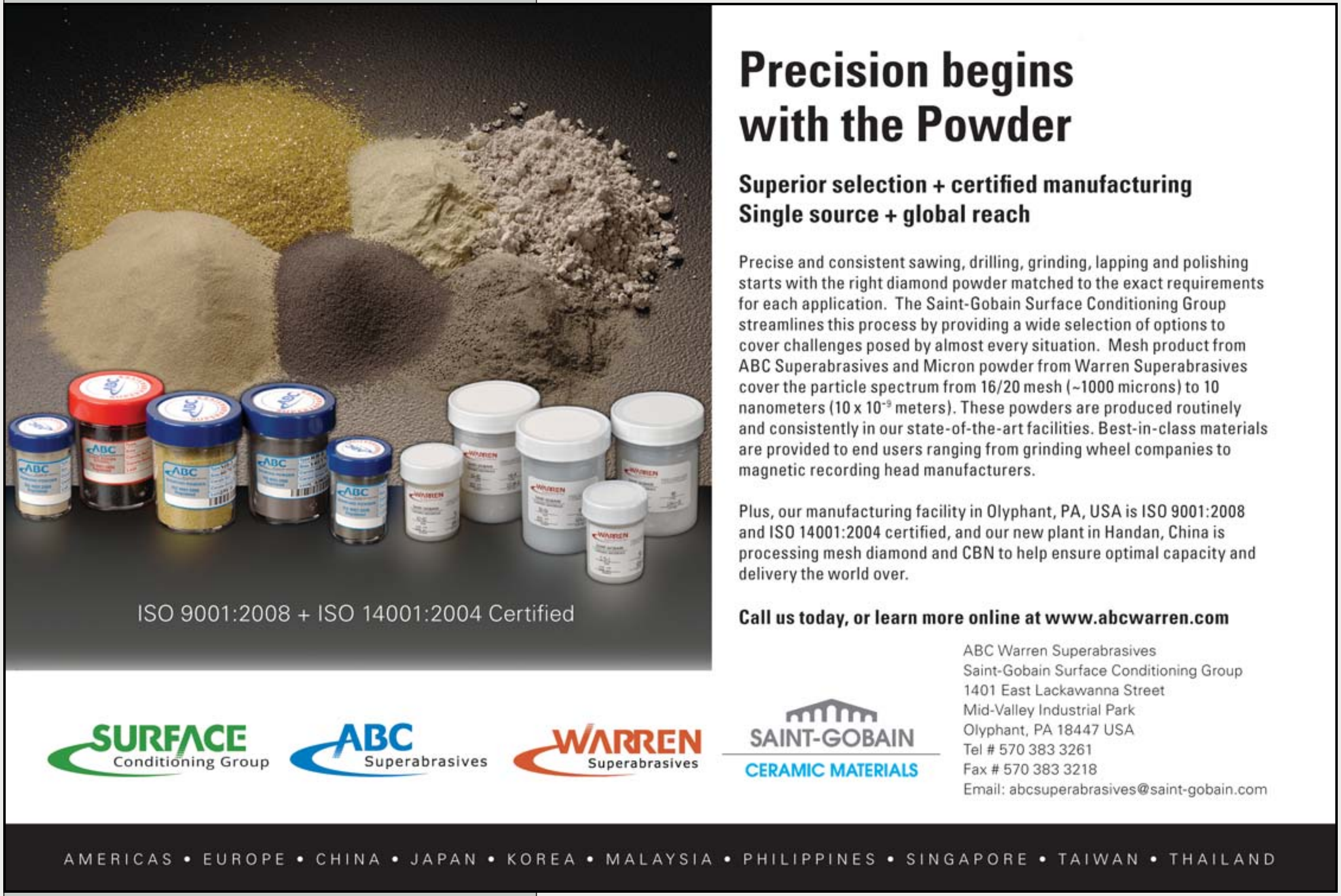
Introduction

Since the first CBN tools were developed, CBN tools were widely applied for various industries, for example, automobile, aircraft, energy and so on. Especially, in automobile industry, CBN tools have shown the excellent performance for machining hardened steel and improved the productivity. However, there are still difficult-to-cut materials even in using CBN tools. Inconel718 is a kind of Ni-based heat resistant alloy and shows good strength at high temperature, corrosion resistance, and heat resistance. Therefore, Inconel718 is mainly used in aerospace industry (e.g. turbine disk of jet engine), and energy industry (e.g. turbine blade of generator). On the contrary, Inconel718 is known for one of the difficult-to-cut materials because of its properties such as strength at high temperature, tendency to be work hardened, and tendency to adhere to machining tool. Therefore, Inconel718 was machined at low cutting speed (~VC = 50 m/min.) with carbide conventionally. However, the production of aircrafts is increasing recently. It is predicted that over 10,000 units will be needed in the near future only in the Asia-Pacific region. [1] So, the demand for high



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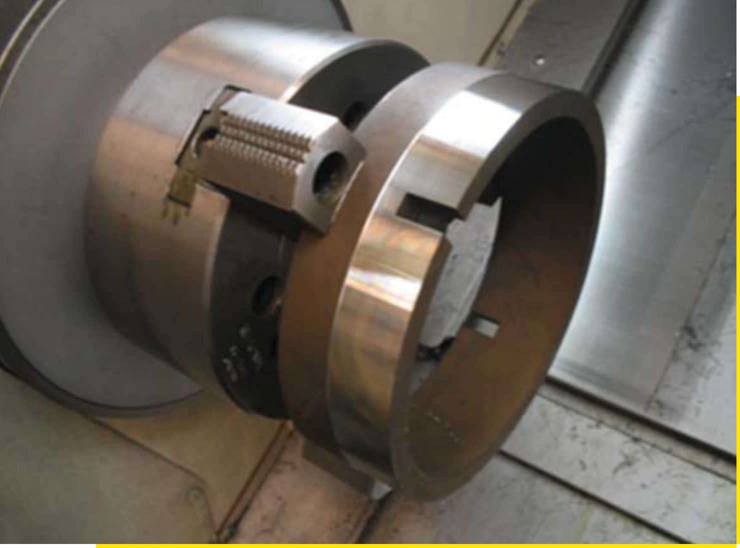
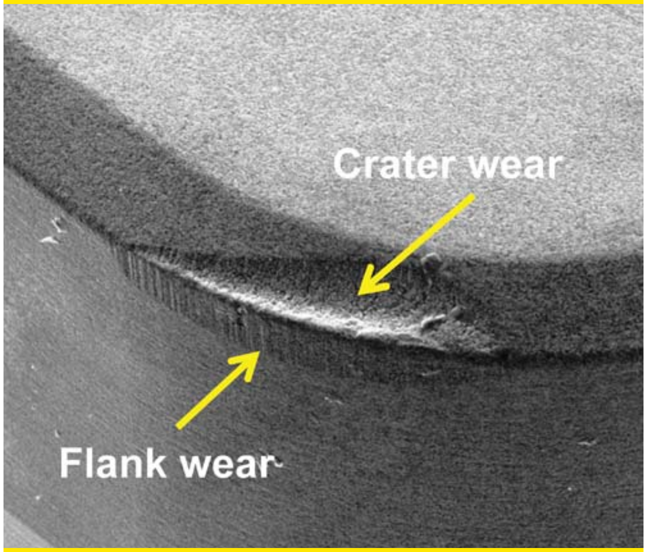


Hard Part Turning – New Grade Series with Enhanced Crater Wear Resistance and Edge Toughness for Applications Ranging from Continuous to Interrupted Applications

ANSHUL SINGH
Diamond Innovations, Inc.



ABSTRACT

Hardened steels (45-68HRc) are utilized in a multitude of applications ranging from power train components, bearings, and gear shafts etc. The exceptional hardness, good thermal resistance, and high thermal conductivity of polycrystalline cubic Boron Nitride (PCBN) has helped it thrive in machining of hardened steels for several years. A new series of PCBN grades focused on hard part turning are presented in this paper. The emphasis of the research was on improvement in tool life, productivity and hence reduced part cost for hard part turning applications. The new PCBN grades demonstrate improved crater wear resistance and edge toughness corresponding to applications ranging from continuous to interrupted turning.

INTRODUCTION

Hard turning is widely accepted as a method to finish components in hardened state and offers advantages in terms of high material removal rates with acceptable part geometry and surface finish. Reduced steps during operation, environmental impact and reduced overall cost are some of the documented benefits of hard turning over finish grinding. Several detailed studies on pros/cons of hard turning have been published over the last several years. Cubic boron nitride (CBN) has been widely accepted as the choice of material for most hard part turning applications. Exceptional hardness, toughness, and thermal properties make it the most suitable material for a wide variety of applications. Historically, the cBN content and binder chemistry have governed the application space that a particular cBN grade is utilized. Typically a high cBN content grade demonstrates superior toughness and abrasive wear resistance.

However, for hardened steel applications, typically a low to medium cBN content grade is considered suitable as it provides "chemical or crater wear" resistance to the insert which is a dominant wear mode in these applications. The chemical composition of the cBN grade is thus an important aspect and can affect properties and performance tremendously and is one of the focus areas for the grade series documented in this paper. Machining of hardened steels (~58-64HRc) presents the challenge of severe and rapid wear progression. Tool life is defined as number of parts that can be machined before the tool needs to be changed. The timing of change (and hence tool life) could depend on a few factors namely loss of surface finish or dimensional accuracy due to flank wear, cutting edge breakthrough due to excessive crater wear (causing weakened edge) and notch wear leading to poor surface finish. Assuming suitable tool geometry used for machining hardened steel in a particular application, wear progression and tool life can be affected by machining conditions that are used during the operation.

Several studies have investigated wear modes and mechanisms governing the formation of crater on the rake face. The most commonly proposed mechanism is chemical interaction between flowing chip and workpiece [1]. Another study concluded the mechanism to be diffusion controlled reaction in an adherent layer formed from workpiece constituents [2, 3]. Interaction between workpiece chemistry and tool material composition has

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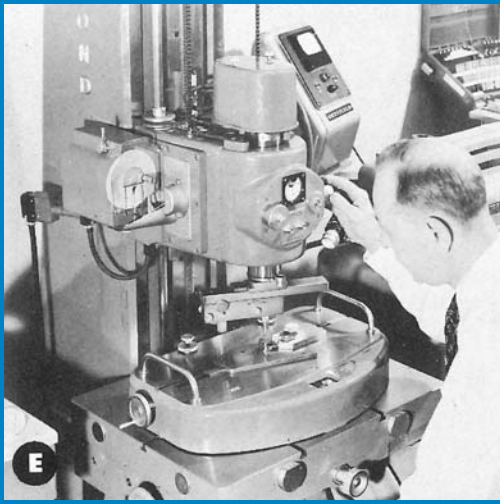

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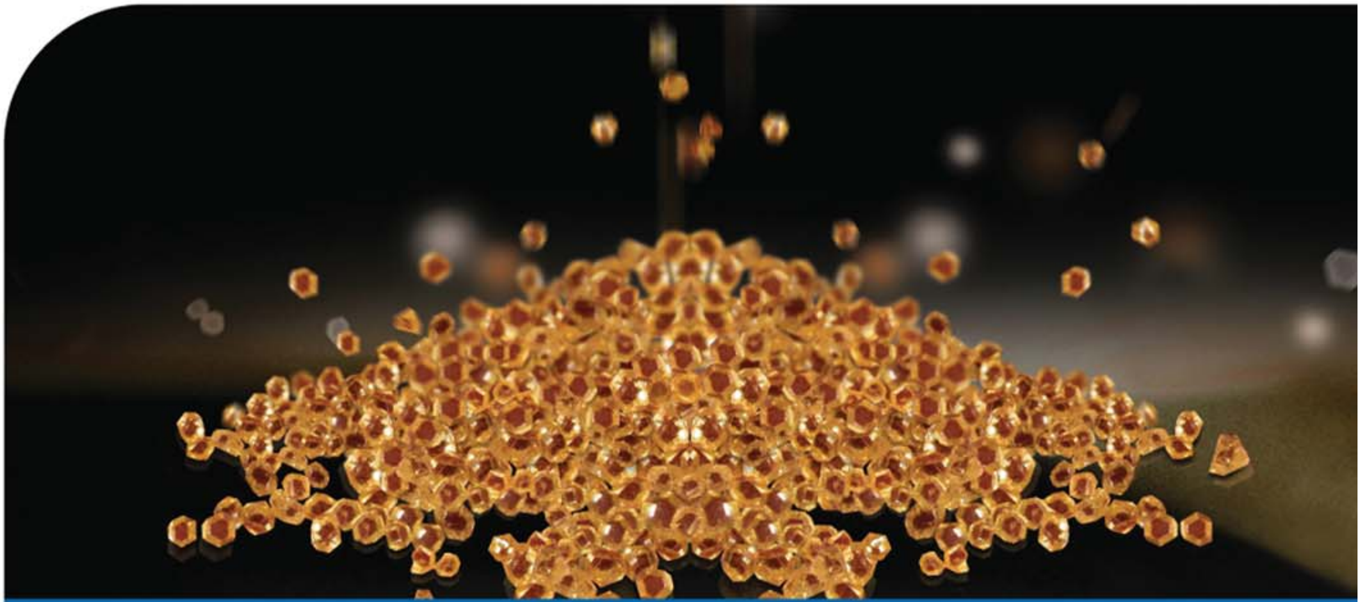

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Paper Excerpts of INTERTECH 2013 on the following pages.

Polishing of Hard to Grind Materials with a Nonwoven Abrasive Wheel Containing Diamond

Rich Crowley Technical Service Engineer
3M Abrasives Systems Division

INTRODUCTION

The usage of nonwoven structures containing conventional abrasive particles for surface modification applications across a broad range of materials is well established. Despite the existence and usage of a wide variety of nonwoven conventional mineral abrasives, the usage of superabrasive mineral in a nonwoven structure is not well established. In this study a diamond nonwoven wheel•s ability to polish the surface of three hard to grind materials will be examined. Tungsten Carbide, D2 Steel, and Non-Porous High Alumina Ceramic have been selected as the test materials and the abrasive used to perform the polishing is a high density nonwoven structure containing 10 micron diamond particles in the form of a 4" diameter by 1/" thick wheel. See Figure 1. and Figure 2.

Nonwoven Abrasives Background

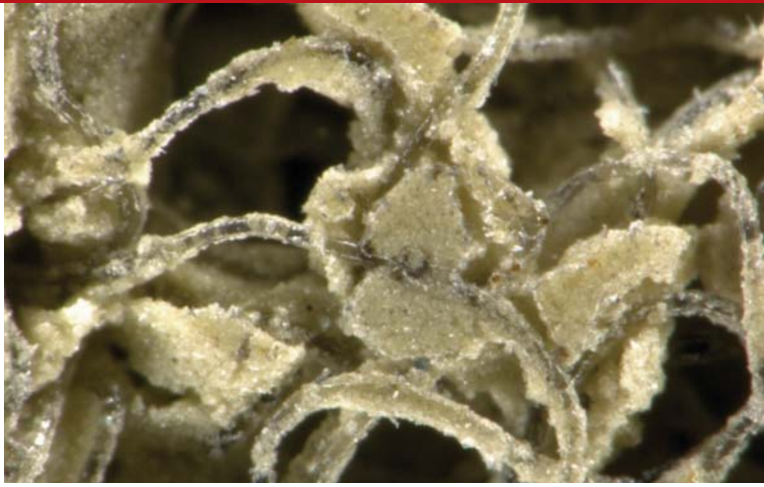
The typical nonwoven abrasive construction consists of a chemical resistant fibers, resin, and abrasive mineral.
See Figure 3.

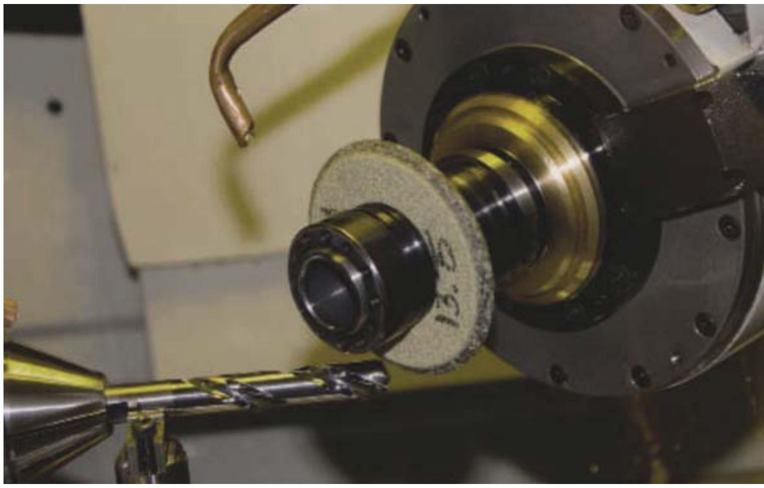
The density and hardness the nonwoven abrasive can be controlled by the manufacturer and the flat sheet form of the starting material can be converted into a number of finished products such as discs, belts, wheels, mandrels, etc.
See Figure 4.

Surface Refinement Mechanism

Compressibility and flexibility are the two key properties nonwovens possess. The abrasive particles attached to the flexible fibers behave like cutting tools riding on a springs . The result is an abrasive particle with two dimensions of freedom to abrade the surface of a material. See Figure 3.

For this reason nonwoven abrasives possess the ability modify the surface layer of a material without changing the material•s base layer. Nonwoven abrasives wheels have an additional feature. The operator can shape the wheel to match the profile of more complex surface geometries such as the flute of a round tool. See Figure 5.

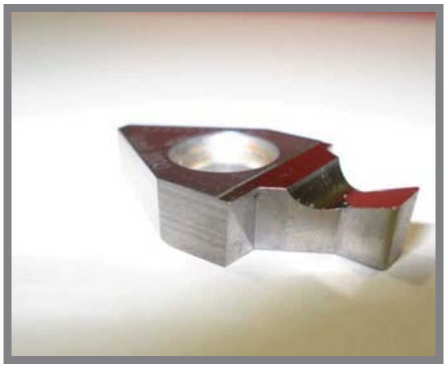


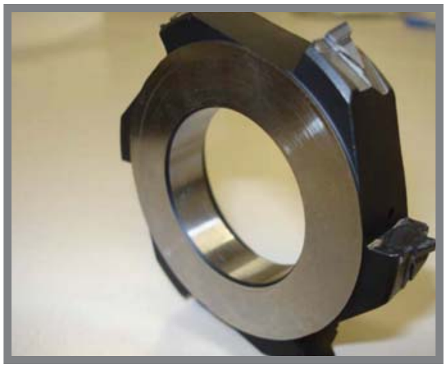


ABSTRACT

The design and performance of diamond in a rigid nonwoven nylon resin structure for polishing hard to grind materials was examined.

Tungsten carbide, D2 Steel, and Non-Porous High Alumina Ceramic were polished with good results in terms of surface refinement and repeatability.





EFFECTS OF ENGINEERED MICRO-GEOMETRY ON BURR FORMATION IN PCD MILLING OF ALUMINUM

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One Wildwood Drive • Cresco, PA USA
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ABSTRACT

In recent years, PCD tools have become the tool of choice in high-speed aluminum milling applications. Burr generation by PCD tools in aluminum milling is the most common reason for tool replacement. Burr generation is significantly impacted by flank wear on the primary cutting edge. Two mechanisms produce flank wear. First, chipping and flaking of the primary cutting edge lead to deterioration of the flank of the tool. Second, frictional rubbing created when flank wear reduces the clearance between the tool and the workpiece generates additional flank wear. Engineered Micro-Geometry (EMG) is a new cutting tool edge preparation technology, which strengthens the cutting edge, and delays flank wear by precisely correlating the size and shape of the cutting edge preparation to the uncut chip thickness.

The purpose of this study was to determine empirically the effects of EMG on burr formation. This was accomplished by conducting tests in a high-speed aluminum milling application, the production of automotive cylinder heads. The study was conducted by running parallel tests on tools with sharp edges and tools prepared with EMG. Test results showed that burr formation was delayed by using EMG. Specifically, tools with EMG ran nearly four times longer than standard PCD tools before burr generation forced tool replacement.

INTRODUCTION

At a macro level, cutting tools produce a stream of chips that constitute the material that is being removed from the work piece. The chip thickness is determined by the penetration of the cutting tool edge into the workpiece. Regardless of whether the metalcutting application is turning, milling, or drilling, the interface of the tool and the workpiece is a narrow band. This band is dimensioned in length by the depth of cut and the width (the most critical dimension) by the forward feed rate of the tool. Depth of cut can be a fairly large amount, but feed rate normally measures only a few thousandths of an inch. The management of this microscopic interface has an enormous impact on cutting system performance.

All cutting tools are produced with an edge preparation. Even “up-sharp” (no edge preparation) is an option. Edge preparation ranges in size from up sharp to as large as 0.008”, depending on the application. The purpose of the edge preparation is to create a cutting edge that will increase the performance of the tool. Properly applied edge preparation will blend and smooth small edge defects and micro-chipping inherent in all hardmetal tooling. The most critical feature of edge preparation is that its size is the same order of magnitude as the thickness of the interface between the cutting tool and the workpiece. Hence, the ratio of the edge preparation to the thickness of the uncut chip is a significant variable in controlling cutting dynamics.

As anyone who has attempted to take a fine finish cut (perhaps 0.001”) with a tool having a large edge preparation (perhaps 0.003”) will attest, the

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The CURRENT STATUS of GRINDING in the MANUFACTURE of TITANIUM ALLOY COMPONENTS

DR. MIKE HITCHINER, OEM Technology Mgr, Saint-Gobain Abrasives, Ann Arbor, MI

SAINT-GOBAIN
ABRASIVES

INTRODUCTION

Titanium is a common industrial metal used extensively throughout the economy due to its very high strength to weight ratio at moderately elevated temperatures, and its corrosion resistance. Specific industries include chemical, marine, biomedical and automotive, but by far the commonest is aerospace and land based power generation; for example titanium alloys represent up to 15% of an aircraft weight. Traditional applications include airframes, fasteners, and numerous low pressure (LP) engine components subject to temperatures of <315 °C.

Titanium is generally alloyed with various other metals in order to control its metallurgy, in particular its phase content. The α phase is stabilized by the addition of aluminum, oxygen and/or nitrogen resulting in a material with the lowest density and strength but the highest creep resistance and ease of machining. The β phase is stabilized by additions of vanadium, chromium, iron, molybdenum and/or manganese resulting in a denser, higher strength material but with lower creep resistance and poorer machinability. (50 – 60)% of the titanium market is the alloy Ti-6Al-4V (TC4) containing 6% aluminum and 4% vanadium to stabilize both the α and β phases thus resulting in a blend of the favorable properties of both - and it is also the least expensive to make! [1]

There are literally hundreds of titanium based alloys available with various other additives and heat treatments (soft annealing, solution treatment and ageing) to raise mechanical properties and maximum operating temperatures. Examples are given in Table I below.

One of the most important recent commercialized materials is gamma titanium aluminide (γTiAl) which is a lamellar structure of stabilized α_2-$\mathrm{Ti_3Al}$ phase sandwiched between layers of a γ-TiAl phase. The boundary of the two phases is interlocking and has almost a “hooked” structure increasing greatly its creep resistance and fracture toughness, and raising its maximum operating temperature to 700-750 °C perhaps even 800°C [4].

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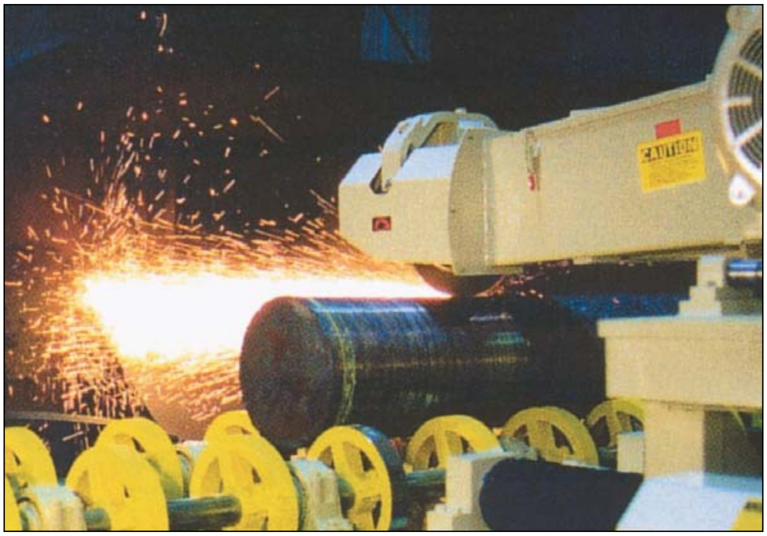

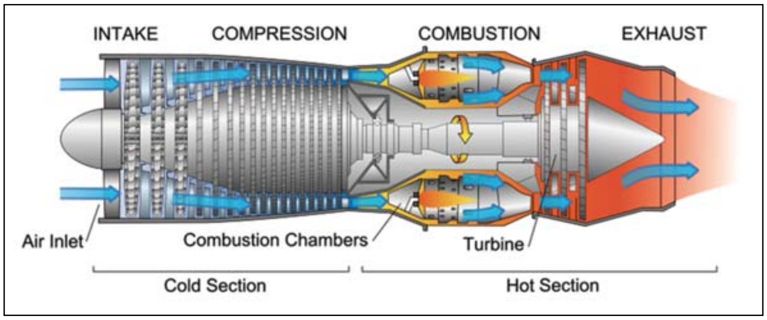

ABSTRACT

Paper reviews the current state of grinding with both conventional and super abrasives for titanium alloys and associated aluminide materials, and its relationship with other machining operations from foundry primary metal manufacture to precision finishing of aerospace components. The paper includes both limitations based on component type, machining interaction and complexity for e.g. engine casings, shafts and fasteners, together with the potential growth of grinding through the introduction of higher temperature resistant, low density yTiAl based alloys for blades and vanes. Performance and grinding conditions are related directly back to material properties especially $(\kappa cp)^{1/2}$

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High Efficiency in Machining Carbon Fiber Composites & Metal Stacks for Aerospace Application

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Introduction

Carbon Fiber Reinforced Plastics (CFRP) has been applied to primary structure of large commercial aircraft, as a means of enhancing overall performance. These aircraft are being developed and produced in a unique way where major OEM's are acting as System Integrators and using Risk Sharing Partners to develop the majority of the principal processes and components. To support this new business and technological model it is necessary that the System Integrator have sufficient knowledge and tools to support the development of the whole manufacturing processes. Of particular interest is the machining of CFRP parts, as they are complex and expensive items, thus offering large opportunities for optimization, in particular when they are stacked to metal parts such as titanium.

Stacking composites and metals such as titanium and aluminum is not new. The materials combination has been around for at least 20 years replacing titanium or aluminum assemblies in high-stress wing areas, such as where the wings join the fuselage. The material theoretically calls for two different tools, one that fits the attributes of a composite and a different one that fits the attributes of the titanium. But only one type of tool can be used in each pass through the hole.

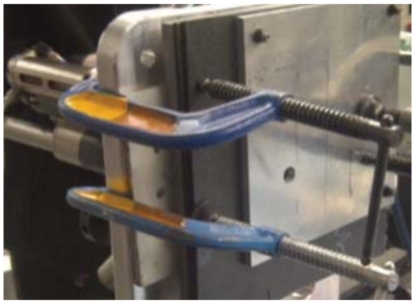
Composites are extremely abrasive, making coated drills the preferred choice. However, PCD as an example of coating doesn't last long when drilling titanium, which creates a great deal of heat. On the other hand, what works in titanium, such as carbide, doesn't last long in composites. Machinists generally end up selecting carbide drills, as wearing out PCD drills in titanium is expensive. The main objective of the present study is the development of a CFRP/Metal drilling tools getting the geometry aspect as a primary focus to achieve drilled holes quality as required by major aerospace drilling specifications.

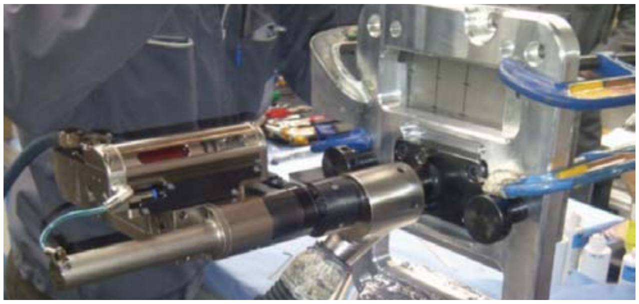
Drilling CFRP/Metal Stacks

Since automated Aerospace assembly sites are looking for one shot drilling CFRP/Metal stacks without any disassembly before riveting the structures, the drilling process development become much aggressive in term of cutter performance giving the highest number of holes

ABSTRACT

Carbon Fiber Reinforced Plastics (CFRP) drilling is a frequently practiced machining process in aerospace industry due to the need for components assembly in aircraft structures. Starting from few decades, research has been conducted to achieve effective drilling of CFRP including studies related to different aspects such as the nature of composites, drilling parameters and hole quality and performance. In this paper, a drilling test program was undertaken for CFRP and metals (Ti-6Al-4V and aluminum Al 7074) stack, with included the identification of optimum drilling process parameters and tooling conditions for application in fastener hole drilling and assembly. Hole quality was first assessed visually, then measured using both geometric and processing response parameters, and finally integrated in a statistical process control (SPC) to allow a clear vision on short and long term production results. Discussion is based on the effect of the stack components (CFRP/Ti/Al) on the choice of drilling parameters (feed rate and cutting speed) and consequently the quality of the hole based on drilling parameters, surface quality, chip evacuation, entry and exit edge integrity. Finally, an optimal operating parameters window for CFRP/Ti/Al stack will be suggested for a secure machining process.





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Winter 2012/2013	INTERTECH 2013 Registration Packet	Dec. 1, 2012
Spring 2013	INTERTECH 2013 Preview	March 1, 2013
Summer 2013	INTERTECH 2013 Review and Highlights	June 1, 2013
Fall 2013	Grinding & Machining Advancements	Sept. 1, 2013
Winter 2013/2014	Superabrasive Industry Review	Dec. 1, 2013
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***Editorial topics & closings subject to change**

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Correlation of Failure Strength with Magnetic Properties and Material Composition of Polycrystalline Diamond

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ABSTRACT

The failure strength of freestanding polycrystalline diamond (PCD) was determined using a burst-disc test. The polycrystalline diamond discs were formed by sintering diamond powder with cobalt infiltration from a cemented tungsten carbide substrate at high pressure-high temperature (HPHT). PCD was produced with diamond grain sizes ranging from 12 to 100 microns. The cobalt content was varied independently by sintering at two different pressures. Measurement of specific magnetic saturation and coercive force were made on each PCD disc and compared to the strength measurements. A model was built from this data to show the relationship between failure strength and the magnetic properties. Diamond grain size and specific permeability (the ratio of the specific magnetic saturation to the coercive force) were found to be accurate indicators of failure strength.

KEYWORDS: Ferromagnetic material, specific magnetic saturation, coercive force, HPHT, sintering, polycrystalline diamond, burst strength.

INTRODUCTION

Conventional polycrystalline diamond cutters (PDC) are made by sintering diamond powder on a cobalt-cemented tungsten carbide (WC-Co) substrate under high pressure-high temperature (HPHT) conditions around 6 GPa and 1400°C. During sintering, cobalt from the substrate melts and infiltrates through the pores among the diamond crystals, acting as a solvent-catalyst for diamond formation. The molten cobalt dissolves carbon atoms from the diamond crystals and quickly saturates. The dissolved carbon precipitates and forms diamond-diamond bonding among the diamond crystals [1]. The sintered polycrystalline diamond (PCD) layer provides abrasion resistance, mechanical strength, and fracture toughness, while the WC-Co substrate provides an interface for attachment.

The diamond table of a typical PDC insert consists of a ferromagnetic cobalt phase and a non-magnetic diamond phase. A small amount of non-magnetic WC is also present in the diamond table. Thus the PDC diamond table is amenable to magnetic property measurements. Magnetic property measurements have been used to assess quality and consistency of cemented carbides for many years [2,3]. Both specific magnetic saturation (ss) and coercive force (Hc) are commonly used for this purpose. The specific magnetic saturation provides a measure of the cobalt content in the diamond table. The coercive force measures the ease with which the ferromagnetic domain walls are aligned by an induced magnetic field. Coercive force has been shown to correlate with mean free path of cobalt in cemented WC [4]. By analogy this should also be a measure of the mean free path of cobalt or degree of diamond intergrowth in PCD.

Since their introduction over 30 years ago, PDC inserts have made a significant impact on the oil and gas drilling industry. Bits equipped with PDC cutters now account for a significant portion of the total footage drilled [5]. High rates of penetration, long life, and simplicity are some of the benefits afforded by PDC bits. However, PDC bits have had limited success at drilling high compressive strength and abrasive rock formations. One of the limitations to hard rock drilling is the propensity of the cutters to break.

New PDC cutter designs must be evaluated for failure strength prior to field application. Lammer showed that the strength of polycrystalline diamond increases as the grain size of the diamond crystals decreases as per the Hall-Petch effect [6,7]. Cobalt content also increases with decreasing grain size, increasing the strength of the PCD. However, Lammer was unable to determine the influence of the cobalt secondary

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Efficient Drilling of Advanced Aerospace Materials with PCD Solutions

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ABSTRACT

Advanced aerospace materials, carbon fiber reinforced plastic (CFRP) alone or stacked with Titanium and Aluminum plates, are widely utilized in aerospace industries for its high strength-weight ratio and stable material properties at demanding environments. Currently connection technologies for the molded parts like gluing or welding are still under question so that fixturing with rivets is still a dominating reliable process in practice. Machining those materials, however, especially in holemaking operations, challenges cutting tools requiring high hardness as well as optimum tool geometries in order to be efficient. To develop premium solutions for those applications significant attentions are being paid in both academic and industrial practices to improve hole quality and machining efficiency at reduced manufacturing cost. Poly-crystal diamond (PCD) shows its great potentials in such applications replacing traditional tungsten-carbide cutting tools for its high wear resistance. A solid carbide drill with brazed PCD tip for CFRP/Ti stacks is developed and introduced to meet the customers• various needs. The drill has a rigid body with two helical flutes allowing high rake angles. Its integrated PCD tip is made of well-balanced average grain-sized PCD grade to provide excellent wear resistance as well as cutting edge toughness. The drill is manufactured with optimum point geometries to enhance self-centering, hole size and exit burr height control. Internal spiral coolant holes, generated with the new manufacturing technology, can be used for either internal high pressure coolant or minimum-quantity lubricant (MQL) applications. Metal cutting tests show remarkable improvements in tool life, hole quality, and machining efficiency with this one-shot solution in contrast with traditional carbide or veined PCD solutions.

INTRODUCTION

Advanced aerospace materials, carbon fiber reinforced plastic (CFRP) alone or stacked with Titanium and Aluminum plates, are widely utilized in aerospace industries for its high strength-weight ratio and stable material properties at demanding environments. Boeing Dreamliner 787 for example, has 80% composites by volume equivalent 50% weight which eliminated 1,500 aluminum sheets and up to 50,000 fasteners, as a result 20% more fuel efficient than Boeing 767 [1]. Currently connection technologies for the molded parts like gluing or welding are still under question so that fixturing with rivets is still a dominating reliable process in practice [2][3]. Due to the substantially different mechanical properties of carbon fibers and metals, drilling fastener holes in those composites challenges cutting tools requiring high wear resistance as well as optimum tool geometries in order to be efficient [4][5][6][7].

Poly-crystalline diamond (PCD) shows great potentials as the cutting tool material in improving machining efficiency compared with traditional tungsten-carbide cutting tools for its high wear resistance in machining of advanced aerospace materials [4][7]. PCD solid drill thus is developed and offered by some leading metal cutting tool manufacturers [7][8][9][10][11]. PCD solid drill is a PCD-enhanced solid carbide drill which combines the PCD as the cutting edges onto a solid carbide drill body. The carbide drill body provides the rigidity and the dimensional accuracy to maintain hole qualities. It also enables to add spiral internal coolant holes and helical flutes to improve cooling and chip evacuation necessary for drilling operation. The functional area, cutting edges are made of PCD which provides the wear resistance to enhance machining efficiency [10].

Optimum tool design is critical to generate good hole quality in machining of advanced aerospace composites. Many essential factors in the course of tool dimensional design play important roles in affecting hole qualities, such as sharper edge radius and larger rake angle to generate lower cutting forces, smaller point angle to reduce less thrust force and fiber delamination, and optimized edge design to improve burr height control. Machine tools, spindle and setup rigidity, tool adaptor, internal or flood coolant, workpiece materials that the drill enters and exits are also important factors need to be considered at tool design. In many cases, customized tools are required to meet various

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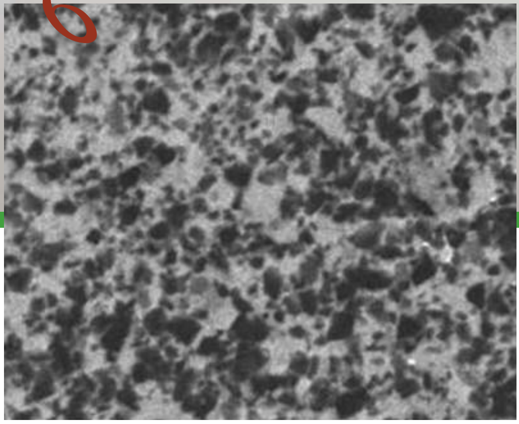

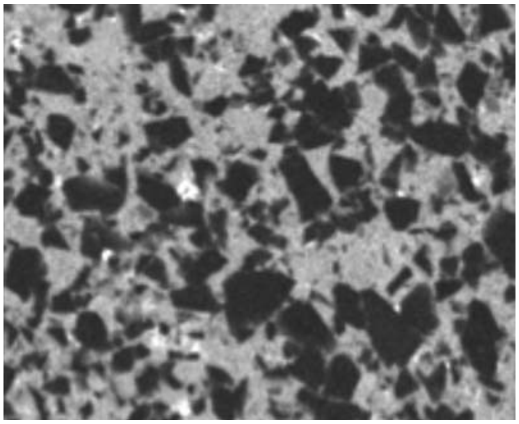

The Development of Solid PCBN Grades with Low CBN Content

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ABSTRACT

The value of low CBN content PCBN tool materials has long been recognized in hardened steels machining, and is increasingly seen as a leading solution for nickel and cobalt-based superalloys. This paper presents the development of low CBN content PCBN disks in large solid formats, of up to 91 mm diameter and 12 mm thickness, and presents benchmark machining tests and results which show that the new solid grades can significantly outperform their carbide-backed counterparts. Discussion of the brazing methods and flexibility in tool geometry afforded by these unique formats and the electrical conductivity of the new materials is also presented.

KEYWORDS: PCBN, Inconel, Solid Format, Low CBN Content

INTRODUCTION

Polycrystalline cubic boron nitride, PCBN, has been widely commercially available since the early 1980's, although the range of available grades and properties was, of course, more limited than today. The value of low CBN (cubic boron nitride) content material was quickly recognised, primarily for the continuous machining of hardened steels [1-3], and PCBN grades were thus broadly separated into high and low CBN content materials. This separation was between grades which had a higher than (approximately) 80% volume CBN content, and were used for cast irons, milling and other interrupted cutting operations, and those grades which had 60% or lower volume CBN content. Low CBN content materials were sold as carbide-backed materials, which allows for easy processing by means of EDM (electrical-discharge machining) and brazing in air with flux using induction or torch methods.

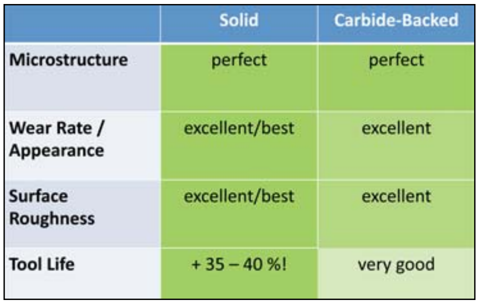
The technical and commercial barriers to developing solid low CBN content grades in the past can therefore be said to be:

- the production of a solid material which is electrically conductive but performs competitively
- the brazing of a PCBN microstructure directly to a carbide insert blank (active brazing)
- grinding (e.g. peripheral grinding) of inserts with a higher thickness of PCBN

The development and now commercial availability of such materials can consequently be considered to be the outcome of both improvements in tool/insert-making technology (improved mechanical and electrical-discharge grinding technology, wider use of active brazing techniques) as well as the technical developments required in synthesis and presynthesis technology, in order to address all of the aforementioned issues.

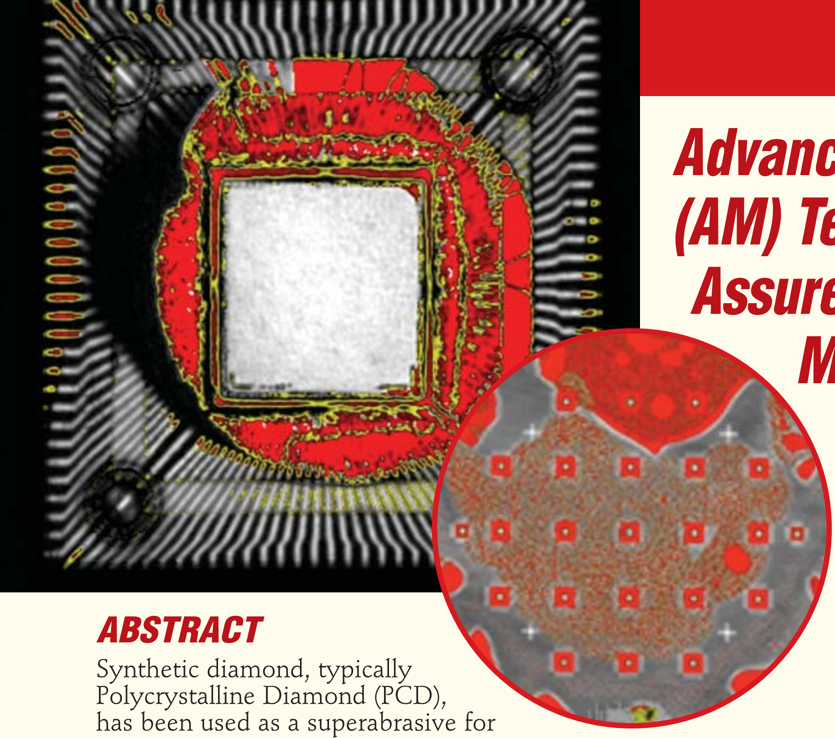
EXPERIMENTAL

2.1 Machine, tool and test parameters



	Solid	Carbide-Backed
Microstructure	perfect	perfect
Wear Rate / Appearance	excellent/best	excellent
Surface Roughness	excellent/best	excellent
Tool Life	+ 35 – 40 %!	very good

The parameters chosen for the test were selected to be representative of the higher end of industry standard values for the dry finishing of hardened steels with PCBN tooling. The principle criterion for ending the test is a chipping of the



Advances in Acoustic Microscopy (AM) Techniques Provide Ways to Assure the Quality and Improve the Manufacturing Process of Polycrystalline Diamond (PCD)

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ABSTRACT

Synthetic diamond, typically Polycrystalline Diamond (PCD), has been used as a superabrasive for cutting tools, inserts, etc., wih great success. However, that success depends on the quality of the synthetic diamond produced and the integrity of the tool structure. In the past, non-destructive techniques such as optical and X-ray techniques have been used with minimal assurance of the synthetic diamond overall quality. Advances in the area of ultrasonic imaging, such as Acoustic Microscopy (AM) techniques, now provide ways to assure quality of PCD tools. AM techniques can be used to measure the percentage (%) of bond achieved, look for hairline cracks, evaluate and measure thickness uniformity and look for porosity/density variations. Advanced AM techniques initially developed for the world of microelectronics and how they can be utilized for synthetic diamond materials and tools made from those materials will be discussed. The same reliability and quality assurance techniques used to ensure that your cell phone, laptop, tablet, etc. work when you need it most can now be applied to the world of superabrasives. These techniques can improve the manufacturing process of synthetic diamonds and tools, plus ensure that reliable, high quality tools are made without fail.

INTRODUCTION

AM (Acoustic Microscopy) is a non-destructive test method that utilizes high frequency ultrasound in the range of 5 MHz to 400 MHz. Ultrasound is sensitive to variations in materials and is particularly sensitive to locating air gaps (delaminations, cracks and voids). There is a direct relationship between ultrasonic frequency, X-Y resolution and penetration

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◆ Provides Safety / Regulatory Reports And Advisement
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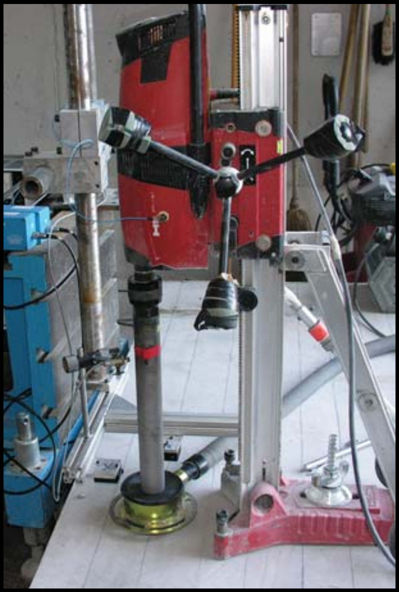

A Comparison of the Abrasive Wear Resistance and the Impact-Fatigue Fracture Resistance of Four PCD Materials

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ABTRACT

Generally, the suitability of PCD materials for rock drilling applications is quantified by using granite log milling tests and drop hammer edge chipping tests, which expose the PCD cutters to uniform loading and very low cycle loading conditions, respectively. The dynamic loading during the drilling of man-made construction materials, which are generally highly inhomogeneous, is not inherent in these tests. Therefore, test methods were devised which more closely represent the actual conditions experienced by cutters used in tools for the construction industry. The paper presents test results from granite log milling tests; concrete turning tests; reinforced concrete turning tests; and impact-fatigue rotary percussive tests on steel (at 20° and 70° back rake angles, approximating to conditions of pure normal force and pure cutting force, respectively) for four different grades of PCD. Results from the four materials in the five laboratory tests are compared and their performance data in actual concrete drilling presented.

INTRODUCTION

Although PCD is successfully used for both rock drilling and metal cutting, up to now it has not been widely applied commercially for the simultaneous cutting of both mineralic and metallic materials, which is the case with steel reinforced concrete used in construction. Hilti still uniquely offers system solutions for dry core drilling with PCD for specialised applications, for example in the dismantling of decommissioned nuclear facilities and drilling in water-sensitive environments such as hospitals, computer server rooms, etc. However, the widespread penetration of this technology into mainstream building and construction markets has not yet occurred and is dependent on reducing specific drilling costs per unit depth, which can only be achieved when the excellent drilling performance is matched by guaranteed reliability and higher lifetime (i.e. drillable depth).

In previous papers, some of the important aspects related to this issue have already been presented. In [1], the wear and fracture mechanisms observed in the PCD cutters were characterized. Gross fracturing from top and side loading (high normal and radial forces) was identified as the primary failure mechanism, followed by wear and chipping from front loading (high cutting forces) in roughly equal proportions. In [2], the influence of drive parameters and core bits designs on drilling performance (speed i.e. rate of penetration and lifetime) was modelled using indentation theory and shown to be sufficiently accurate to support testing-based product development.

This paper focuses on some of the experimental findings from laboratory testing and concrete drilling. The laboratory test methods used were developed to be closely representative of the actual conditions experienced by cutters used in

KEY WORDS

Polycrystalline Diamond; PCD;
Wear Testing; Impact Testing;
Reinforced Concrete; Drilling

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